

X-611-68-348

PREPRINT

NASA TM X-63331

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GPO PRICE \$ \_\_\_\_\_

CSFTI PRICE(S) \$ \_\_\_\_\_

Hard copy (HC) 3.00

Microfiche (MF) .65

SEPTEMBER 1968

ff 653 July 65



**GODDARD SPACE FLIGHT CENTER**  
**GREENBELT, MARYLAND**

FACILITY FORM 602

N 68-34690

(ACCESSION NUMBER)

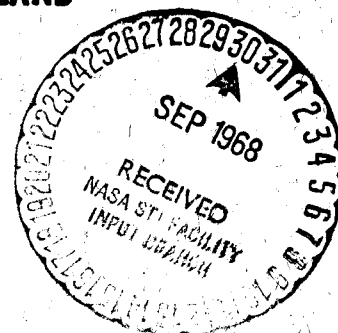
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1  
(CODE)

TMX-63331  
(NASA CR OR TMX OR AD NUMBER)

30  
(CATEGORY)



# An X-Ray Test For Superdense Stars

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Strong thermal x-ray emission from a small source ( $\sim 10^6$  cm) is a signature to be expected from a superdense star, such as a neutron star (Wheeler, 1966). It is the purpose of this letter to point out that the superdense star hypothesis for a thermal x-ray source may be tested by measuring the statistical fluctuations in the observed x-ray photon count. As an example, this is shown to be a practical test for the x-ray star Sco X-1.

As first noted by Einstein (1909-1912) and much discussed recently in connection with quantum optics (Mandel and Wolf, 1965, McLean and Pike, 1965), the photon count ( $n$ ) for a thermal source exhibits a statistical variance given by

$$(1) \quad \langle (n - \langle n \rangle)^2 \rangle = \langle n \rangle (1 + \delta)$$

where  $\delta$  is the expectation value for the photon population per unit cell ( $h^3$ ) of phase space, for each of the two spin degrees of freedom.

For independent classical particles the variance would include only the first term of (1); i.e. the variance would be  $\langle n \rangle$ . However, photons are Bosons associated with fields that interfere and hence are not completely independent. The value of  $\delta$  gives the deviation from the classical particle statistical variance in the count to be expected for thermal photons.

The quantity  $\delta$  of Equation 1 may be expressed as

$$(2) \quad \delta = \frac{\lambda^3}{2c} \cdot \left( \frac{I}{\Omega} \right)$$

where  $I$  is the spectral intensity (ergs/erg-cm<sup>2</sup>-sec) at a wavelength  $\lambda$ , from a source that subtends a solid angle  $\Omega$ ; ( $c$ ) is the velocity of light.

Note that the relation (2) between the measured variance of the photon count (1) and the measured spectral intensity ( $I$ ) at  $\lambda$  gives the solid angle  $\Omega$  subtended by the source when this information refers to thermal radiation; a small source enhances the statistical variance.

The x-ray source Sco X-1 has been measured (Gursky et al, 1965) to be a stellar (< 20") object and the optical counterpart is estimated to be at a distance of about  $8 \times 10^2$  light years (Sandage et al, 1966). If Sco X-1 is a superdense star (Shklovsky, 1967) of radius  $r \approx 10^6$  cm, then the angular size of the source is about  $10^{-9}$  arc seconds, which is far beyond the angular resolution capability ( $\sim 1$  arc second) of the grazing incidence x-ray telescope (Vaiana et al, 1968). In contrast, for the intensity from Sco X-1 measured (Grader et al, 1968) at  $\lambda = 10\text{\AA}$  ( $I \approx 10^2$  ergs/erg-cm<sup>2</sup>-sec), the situation of a superdense star of radius  $r \approx 10^6$  cm as the source of x-rays would give the significantly large value of  $\delta = 1/3$ . That this is a sensitive measure of the size of a small source may be realized by noting that for an alternate hypothetical situation where Sco X-1 is comparable in size to the sun ( $r \approx 10^{11}$  cm) the enhanced fluctuations would essentially vanish since in this case  $\delta < 10^{-10}$ .

It is a pleasure to thank William Johnston for valuable discussions.

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